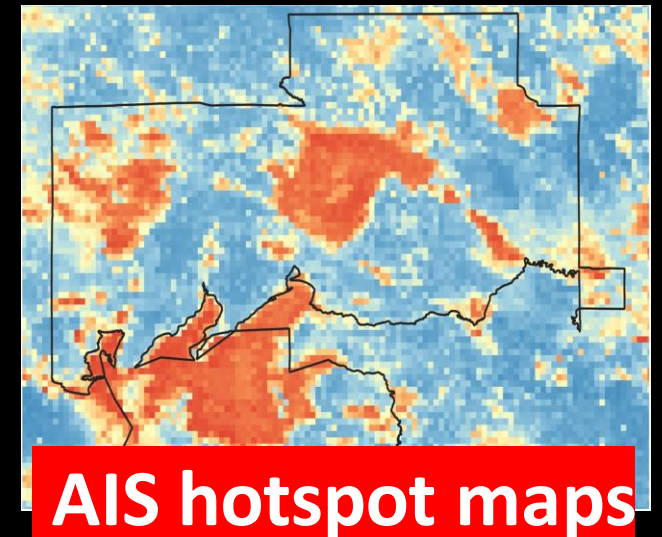
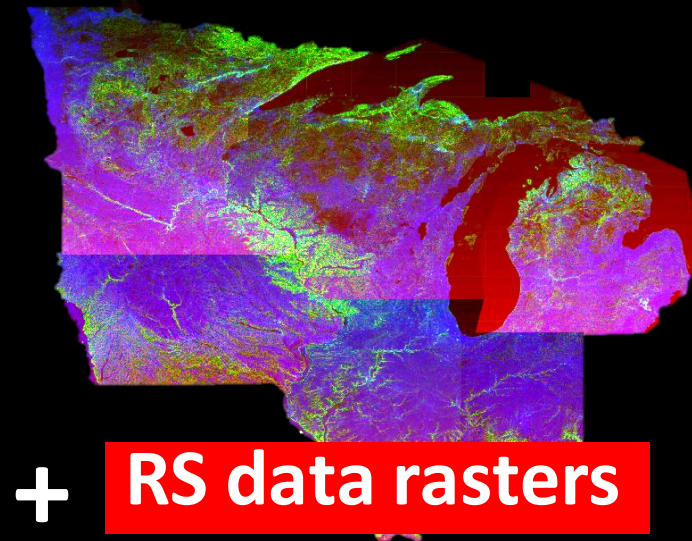
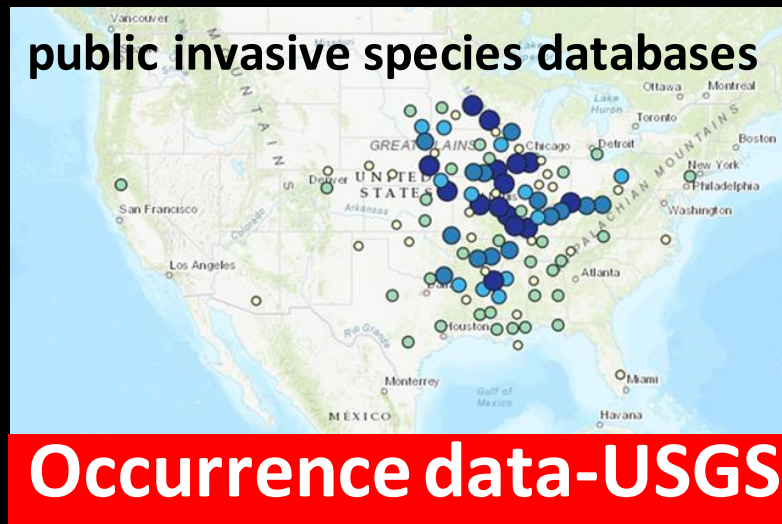


# Projecting Spread of Aquatic Invasive Species Using **Remote Sensing Data & Species-Distribution Modeling** with eDNA

**Leif Howard**<sup>1,2</sup>, Charles van Rees<sup>1</sup>, Wes Daniel<sup>3</sup>, Matthew Nielson<sup>3</sup>, John Kimball (co-PI)<sup>2,3</sup>, Brian Hand (co-PI)<sup>1,2</sup>, Gordon Luikart (PI)<sup>1,2</sup>, **Roozbeh Valavi**<sup>4</sup>



1



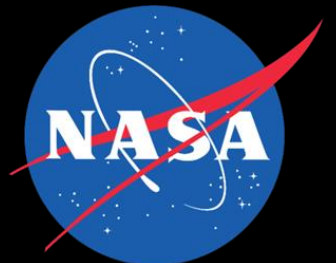
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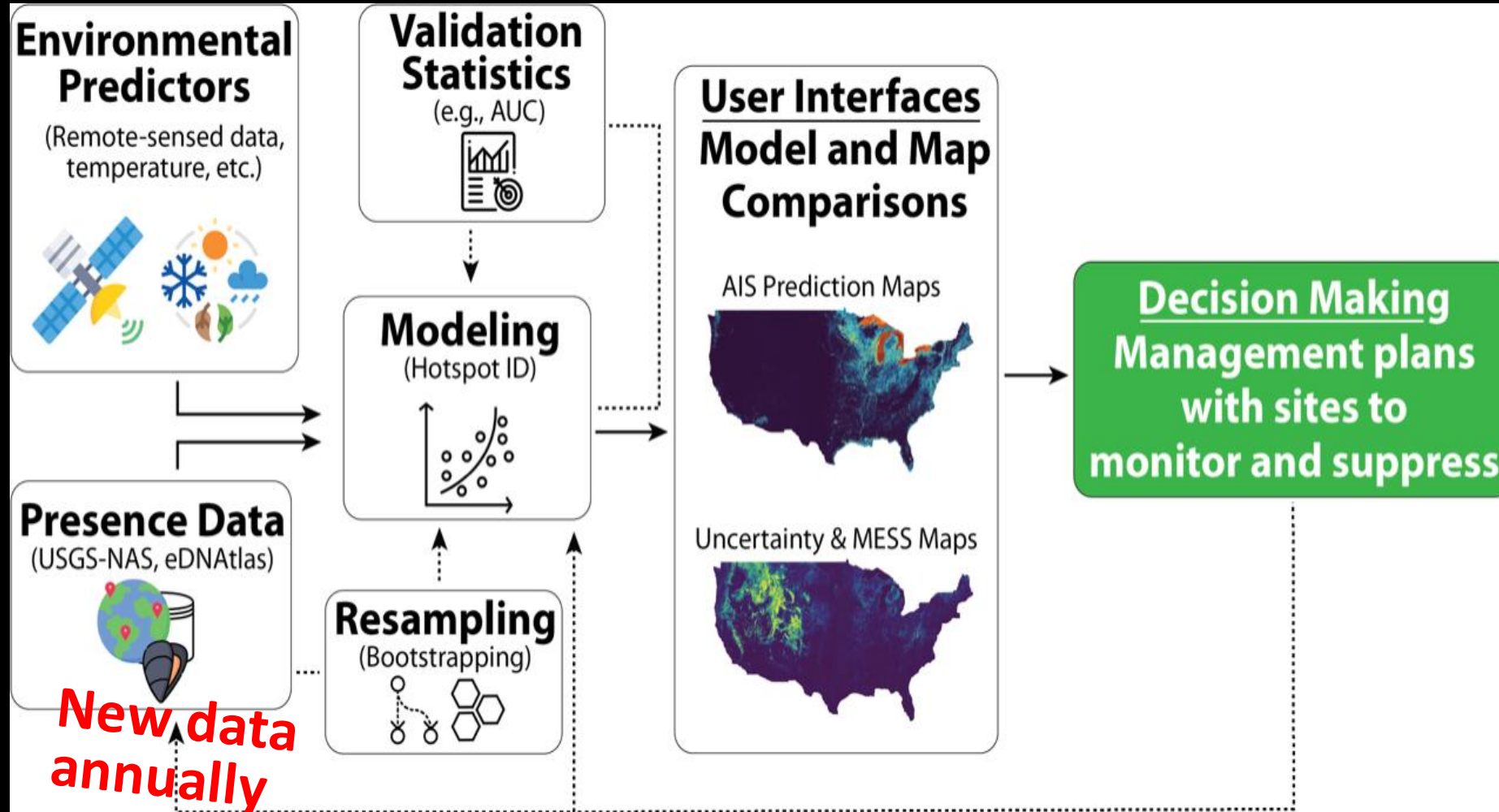
3



4



**We have a workflow and software (ARL-5) for managers to build species-distribution models & heat maps predicting AIS hotspots**



**Update models & maps frequently  
(on Google Earth Engine or local computer)**

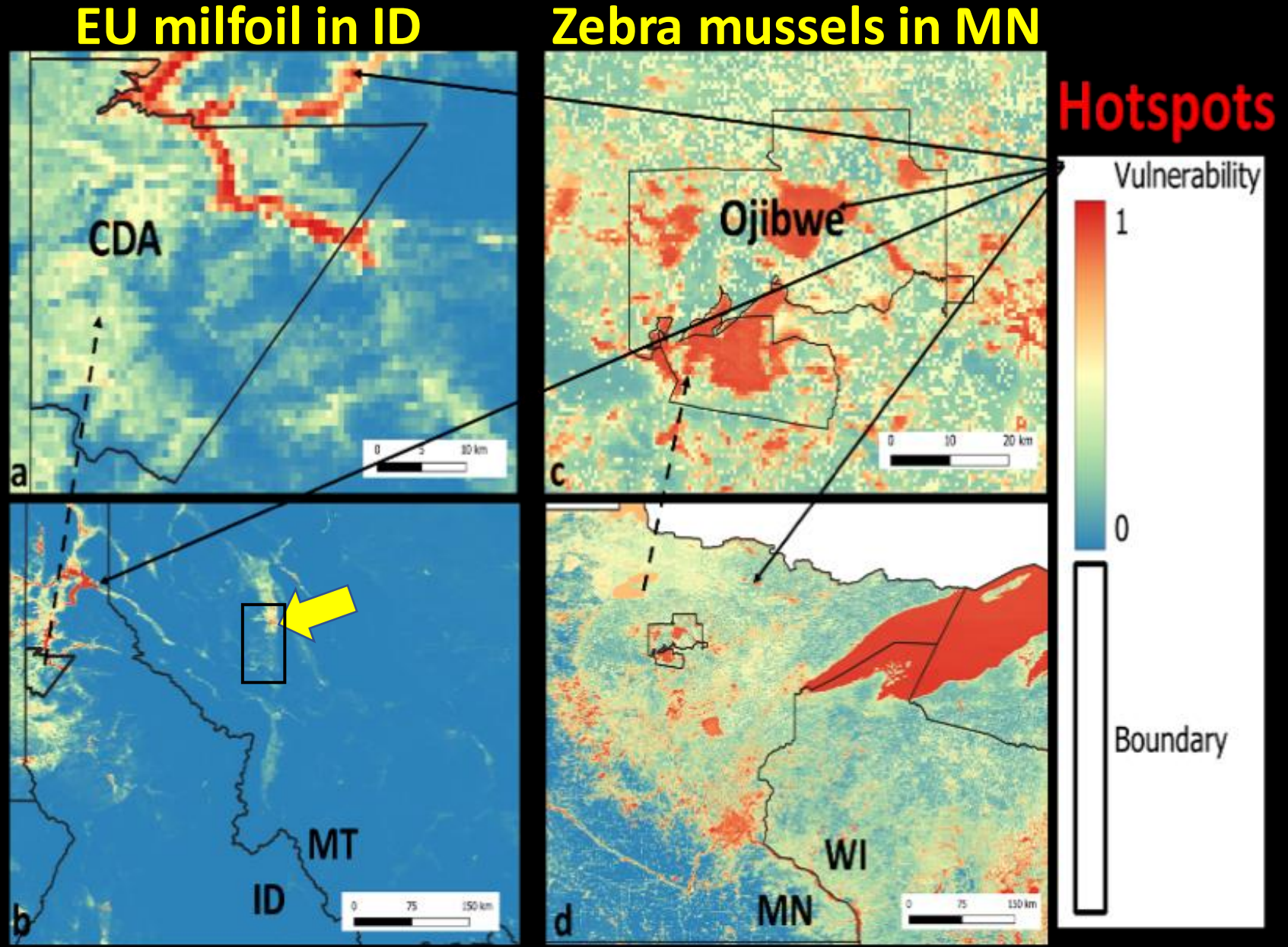
**Workflow:**  
promotes annual  
revision of multi-  
species hotspot  
rankings  
(Van Reese et al.  
2022)



# Prototype heat maps of invasion risk from our workflow

**Maps from ML Models (MaxEnt)** integrating occurrence data & remotely-sensed data (including Landsat 9 and MODIS V061)

**Main Env. Predictors:**  
Flashiness/flooding, LST, GPP, elevation  
(Howard et al. in prep)





# Training & AIS sampling with managers in Minnesota

Head waters of the Mississippi River

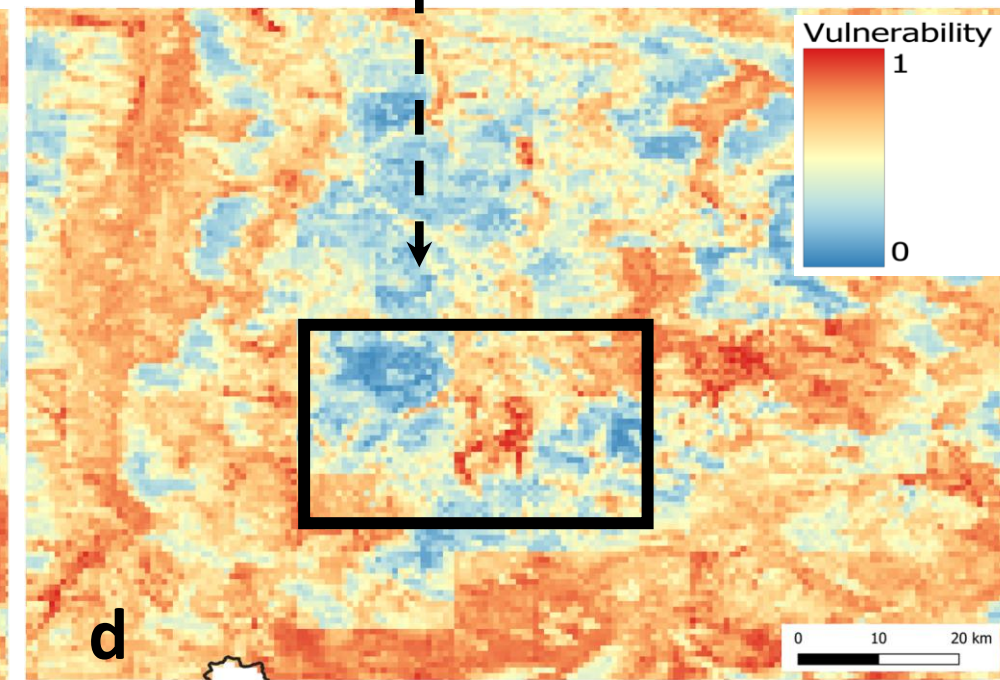
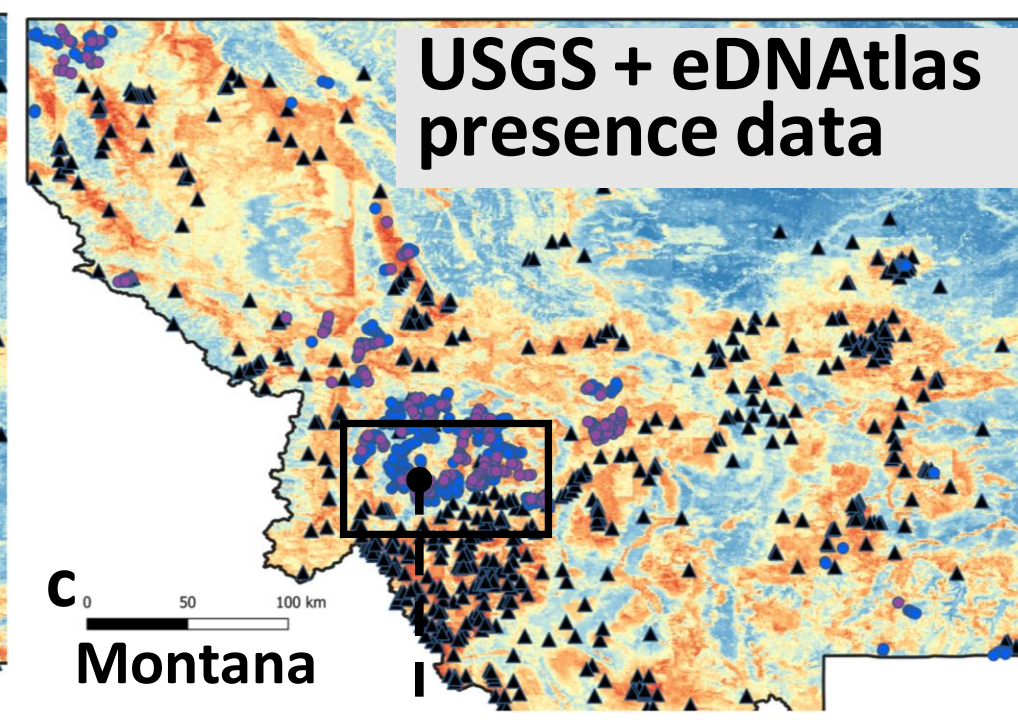
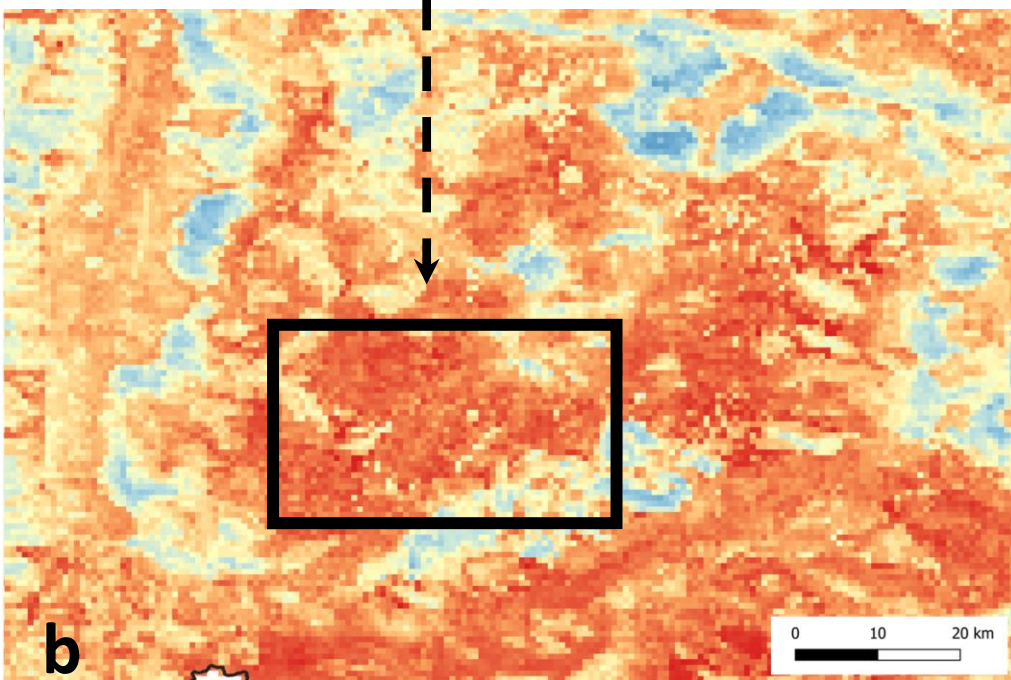
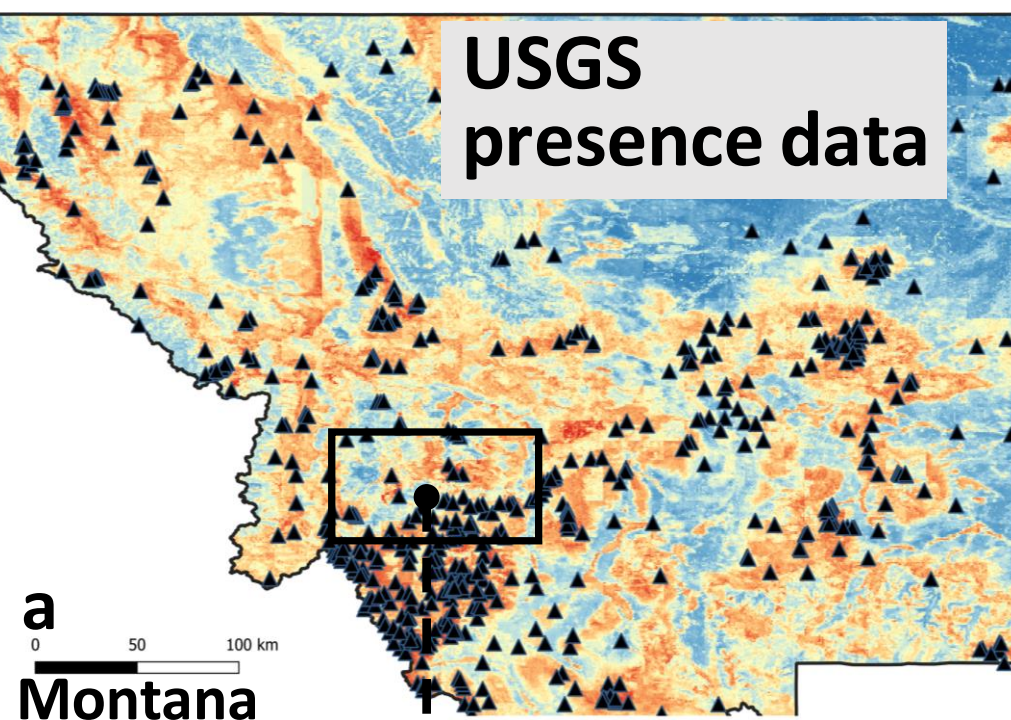


Tow-net sampling eDNA



**Tribes manage 56 million acres, 2<sup>nd</sup> only to the US Gov. in land area.**





**Adding new  
(eDNA) data  
improves  
resolution  
of hotspots**

**Legend**

- eDNA Absence
- eDNA Presence
- ▲ NAS Presence
- Boundary

**Brook trout**





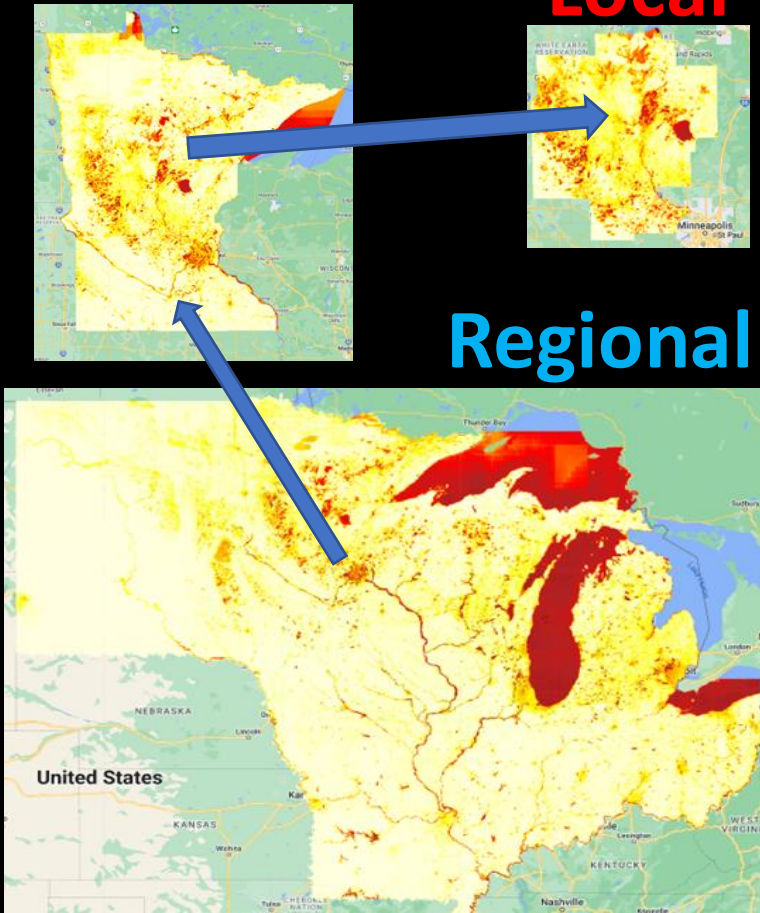
# False negative prediction rates for **5 taxa** at **3** spatial scales

**45 MaxEnt models**

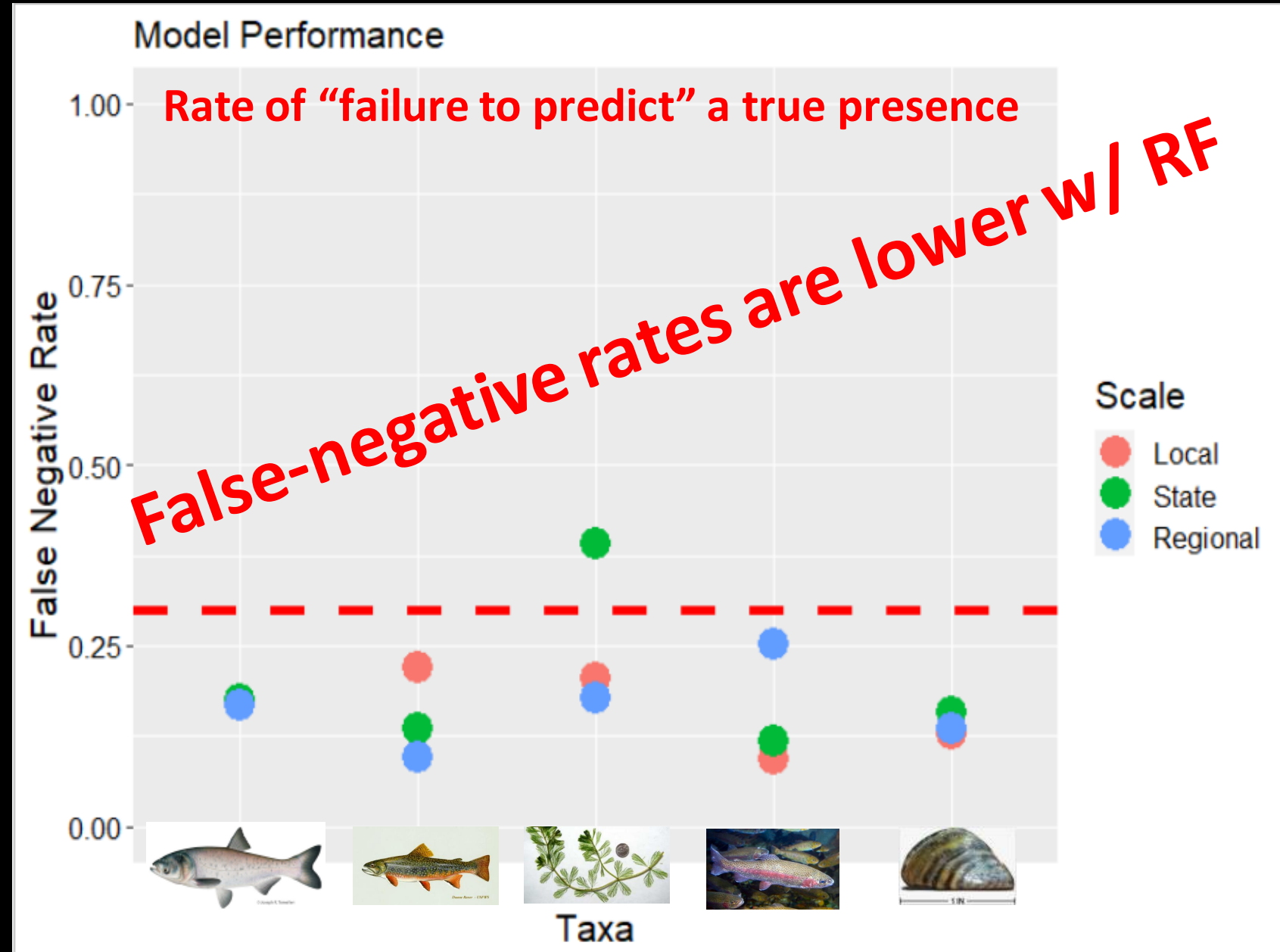
**State**

**Local**

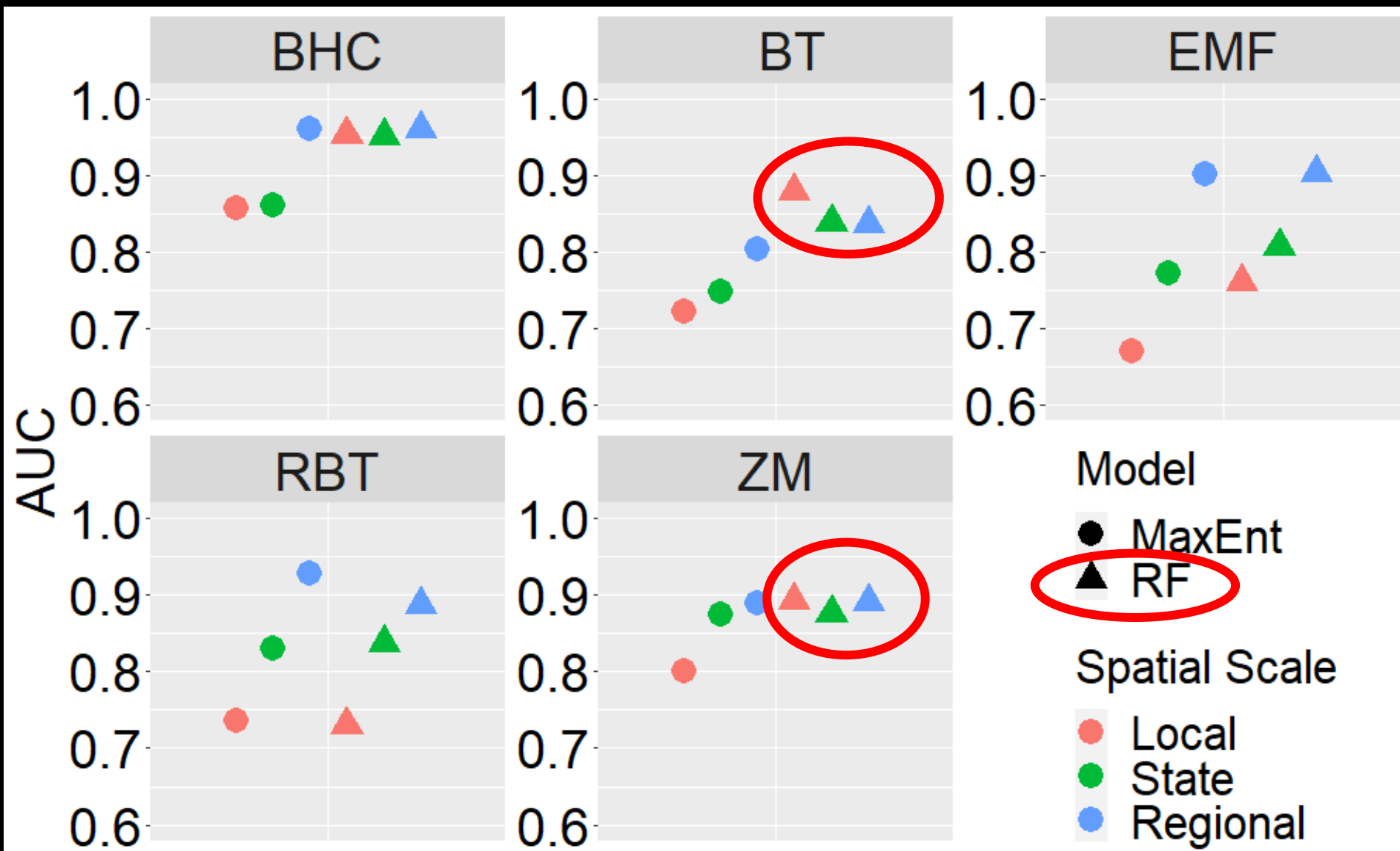
**Regional**



(Howard et al. in prep)



# AUC: Random Forests models perform better than MaxEnt



**A model whose predictions are 100% correct has an AUC of 1.0**

**AUC (area under the curve) metric for model testing (e.g. train with 75% of data & test on 25%)**

**(See also Valavi et al. 2022)**

# Summary & Conclusions:

Remote sensing and occurrence data (USGS-NAS, eDNAAtlas) are useful in ML-models to map, rank, and predicted hotspots of AIS spread.

Our ARL-5 tools are used by and housed by end users (e.g., Coeur d'Alene & Ojibwe Tribes), also on Google EE, and soon on USGS-NAS.

eDNA data have great untapped potential to improve the use of SDMs and AIS management.

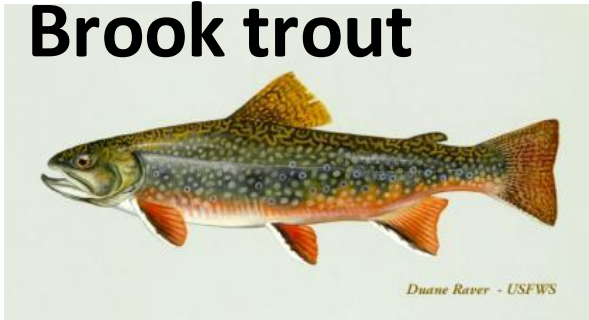
Howard et al. (in prep)





# Questions (later?)

**Brook trout**



**Eurasian watermilfoil**



**Bighead Carp**



**Rainbow trout**



**Zebra mussels**



Environmental Predictor	Source	GEE Asset	Calculation	Units	Resolution	Description	Ecological Connection
Land Surface Temperature	MODIS AQUA LST MYD11A2 (V6; Wan et al., 2015)	ee.ImageCollection("MODIS/006/MYD11A2")	Yearly Maximum	Kelvin	1 km	Temperature on the surface of the Earth measured using thermal infrared passive sensors	Maximum annual temperature record
Precipitation	National Land Data Assimilation System (NLDAS; Mitchell 2004)	ee.ImageCollection("NAS A/NLDAS/FORA0125_H0 02")	Seasonal Total	kg/m2	0.125 arc degrees= 10 km	Rain and snow accumulation, interpolated from weather stations and integrated with actively sensed radar products	Magnitude of peak flow events
Flashiness	USGS Dynamic Surface Water Extent Product (Jones 2018)	ee.ImageCollection("JRC/ GSW1_2/MonthlyHistory")	Per-Pixel SD	Unitless	30 m	Annual per-pixel variation of a dynamic surface water extent algorithm; Derived from Landsat satellite imagery	Flood disturbances; seasonal flow variation
Topographic Diversity	Theobald et al. (2015)	ee.Image("CSP/ERGo/1_0/ Global/ALOS_topoDiversity")	Unprocessed	Unitless	90 m	Variation in temperature and moisture conditions available to species	Habitat complexity
Gross Primary Productivity	Robinson et al. (2018)	ee.ImageCollection("UMT/ NTSG/v2/LANDSAT/GPP ")	Yearly mean	Kg C/m2/ 16-days	30 m	Amount of carbon captured by plants in an ecosystem; Derived from Landsat satellite imagery	Carbon available in the system
Normalized Difference Vegetation Index	MODIS AQUA MYD13A2 (V6) Vegetation Indices	ee.ImageCollection("MODIS/006/MYD13A2")	Yearly mean	Unitless	250 m	Density of “greenness” on landscape	Photosynthetic activity
Enhanced Vegetation Index	MODIS AQUA MYD13A2 (V6) Vegetation Indices	ee.ImageCollection("MODIS/006/MYD13A2")	Yearly mean	Unitless	250 m	Modified vegetation index that reduces atmospheric contamination and maintains sensitivity over dense vegetation	Photosynthetic activity relative to canopy structure



## **Example AIS and their main impacts (*in parentheses*), with selected environmental factors affecting their spread**

<b>AIS Species (impacts)</b>	<b>Environmental predictor variable</b>	<b>RSD products (geo data) describing environmental conditions of interest</b>
Rainbow <sup>1</sup> and Brook trout ( <i>hybridization, competition</i> )	Temperature, stream flow/ Flashiness, partial barriers (e.g., beaver ponds, roads, etc.)	Surface water cover dynamics (Landsat), Stream temperature (NorWeST), Vegetation cover (MODIS, Landsat), LST (MODIS, Landsat TIR), Land cover (Landsat NLCD), fire disturbance (MTBS)

**\*Flashiness, Annual Max LST, Mean GPP, and elevation are top predictors for our nation's five most problematic AIS..**